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An apparatus and a method for optical spectroscopy and for optical sensory technology and use of the apparatus

Claims

1. An apparatus for optical spectroscopy, comprising means for the generation of an interference pattern and comprising means for the coupling of the incoming light field to be examined such that only one or several individual spatial modes of the field are permitted and comprising a detector which can record the intensity of the generated interference pattern at a plurality of spatially different positions, with the wavefronts and/or the propagation direction of at least one of the light fields involved in the interference pattern being changed by spectrally dispersive or diffractive optical elements in dependence on the wavelength.

2. An apparatus in accordance with claim 1, wherein the means for the generation of the interference pattern include a division of the amplitude of the incident light.

3. An apparatus in accordance with either of claims 1 or 2, wherein the means for the generation of the interference pattern include a splitting of the wavefront of the incident light.

4. An apparatus in accordance with any of the claims 1 to 3, wherein the means for the coupling of the incoming light to be examined only permit precisely one defined spatial mode (spatial single mode).

5. An apparatus in accordance with one or more of claims 1 to 4, wherein the means for the coupling of the incoming light to be examined include a spatial filter.

6. An apparatus in accordance with one or more of claims 1 to 5, wherein the means for the coupling of the incoming light to be examined include a mono-mode light guide (single mode fiber).

7. An apparatus in accordance with one or more of claims 1 to 6, wherein the detector can be moved through the interference pattern with respect to one or two spatial degrees of freedom (scanning detector).

8. An apparatus in accordance with one or more of claims 1 to 7, wherein the interference pattern can be imaged onto the detector via optical elements movable with respect to one or two spatial degrees of freedom (scanning detector).

9. An apparatus in accordance with one or more of claims 1 to 8, wherein it has a spatially one-dimensionally resolving detector (array detector).

10. An apparatus in accordance with one or more of claims 1 to 8, wherein it has a spatially two-dimensionally resolving detector (array detector).

11. An apparatus in accordance with one or more of the preceding claims, characterized by at least one diffractive optical element which has non-periodic diffraction structures.

12. An apparatus in accordance with one or more of the preceding claims, wherein the beam splitter(s) influence the wavefront of at least one of the partial beams or light fields in dependence on the wavelength (spectrally dispersive beam splitter).

13. An apparatus in accordance with one or more of the preceding claims, wherein optical elements influence the wavefront and/or the optical path length of at least one of the partial beams or light fields in dependence on the wavelength (spectrally dispersive optical elements).

14. An apparatus in accordance with one or more of the preceding claims, characterized by means which permit a change or modulation of the relative phasing (phase shifter / phase modulator) of at least one of the partial beams or light fields.

15. An apparatus in accordance with one or more of the preceding claims, characterized by means which permit a change or modulation of the spatial position (translation and/or tilting) of at least one of the partial fields and/or of the incident light field.

16. An apparatus in accordance with one or more of the preceding claims, wherein the apparatus or parts of the apparatus forms/form an optical resonator.

17. An apparatus in accordance with claim 16, wherein one or more wavelength-dependent elements are arranged at the interior of the resonator or at least one element of the resonator is made dependent on the wavelength (spectrally dispersive element).

18. An apparatus in accordance with one or more of the preceding claims, wherein the apparatus or parts of the apparatus is/are made in multiple form.

19. An apparatus in accordance with one or more of the preceding claims, wherein the difference of the optical path lengths of the beams or light fields brought to interference can be changed.

20. An apparatus in accordance with one or more of the preceding claims, wherein the apparatus has means for the adjustment of the path length difference of the partial beams or light fields brought to interference, whereby a selection of light components contributing to the interference can be carried out in accordance with their coherence properties (coherence length).

21. An apparatus in accordance with one or more of the preceding claims, wherein the interferometer includes a retroreflector or a dieder.

22. An apparatus in accordance with one or more of the preceding claims, wherein the apparatus has means for the rotation of the interferometer or means for the changing or for the selection of the angle of incidence which permit an adjustment of the spatial frequency or of the spatial frequencies of the generated interference pattern.

23. An apparatus in accordance with one or more of the preceding claims, wherein the apparatus has means for the change of position of components of the apparatus, in particular means for the rotation of the components which

permit an adjustment of the spatial frequency or of the spatial frequencies of the generated interference pattern.

24. An apparatus in accordance with one or more of the preceding claims, wherein the change of the relative phasing of the interfering partial beams or light fields and the change of the spatial frequency or of the spatial frequencies of the generated interference pattern takes place jointly by a movement of at least one component of the apparatus.

25. An apparatus in accordance with one or more of the preceding claims, wherein the spectrally dispersive or diffractive element is a multiplex grating, a multiplex hologram, a holographically optical element or a computer-generated hologram.

26. An apparatus in accordance with one or more of the preceding claims, wherein the resulting interference pattern or parts of the interference pattern include a plurality of spatial frequencies and/or include a continuous spectrum of spatial frequencies.

27. An apparatus in accordance with one or more of the preceding claims, wherein a diffractive optical element is simultaneously used as a beam splitter and as a wavelength-dispersive element.

28. An apparatus in accordance with claim 27 comprising a diffractive element used as a beam splitter, wherein the means for the generation of the interference pattern include precisely this or a similar element for the recombination of the split beams or light fields.

29. An apparatus in accordance with either of claims 27 or 28, wherein the partial beams or light fields are generated by a diffraction grating at different orders

of diffraction and, optionally, including the non-diffracted or reflected partial beam or light field ("0th order"), are reflected back to the diffraction grating by suitable means and from there are again superimposed by diffraction of different orders.

30. An apparatus in accordance with either of claims 28 and 29, wherein two mirrors are provided by which the partial fields starting from the diffraction grating or from the diffractive optical element are reflected back to just this diffraction grating or diffractive optical element, with at least one of the mirrors being arranged moveable such that the relative phase position of the reflected light is changeable and with the coupled light first being split at the diffraction grating or at the diffractive optical element such that a reflected portion reaches one of the mirrors, whereas a diffracted portion reaches the other mirror, and with the portions of the fields reflected by from the mirrors to the diffraction grating or to the diffractive optical element being superimposed again at the detector by the diffraction grating or the diffractive optical element such that a portion of the partial field previously reflected at the diffraction grating or at the diffractive optical element reaches the detector by diffraction, whereas a portion of the partial field previously diffracted at the diffraction grating or at the diffractive optical element reaches the detector by reflection.

31. An apparatus in accordance with one or more of the preceding claims, wherein an imaging optical system and a aperture are provided in the image plane of the beam path.

32. An apparatus in accordance with one or more of the preceding claims, wherein the detector has a spatial mask which correlates with at least one interference pattern to be detected (optical correlator), with the mask being able to be designed in fixed or changeable form (spatial light modulator).

33. An apparatus in accordance with one or more of the preceding claims, wherein the capability of the detector to detect a spatial modulation is realized such that a detector which is primarily non-spatially resolving is combined with a suitable spatial, optionally movable, mask.

34. An apparatus in accordance with one or more of the preceding claims, in combination with a spectrally selective filter and/or a spectrally selective detector.

35. Use of an apparatus in accordance with one or more of the preceding claims as an optical spectrometer.

36. Use of an apparatus in accordance with one or more of the preceding claims for optical spectroscopy, wherein components of the incident light are measured selectively in accordance with their coherence lengths or coherence properties in accordance with the respectively set path length difference of the interfering partial beams.

37. Use of an apparatus in accordance with one or more of the preceding claims as chemometrical sensor.

38. Use of an apparatus in accordance with one or more of the preceding claims as a film thickness measuring unit or as a spacing sensor.

39. A method of determining the optical spectrum and/or of measured values coded or transmitted by an optical spectrum by analysis of the interference pattern measured using an apparatus in accordance with any of claims 1 to 34 or using an apparatus in accordance with any of claims 35 to 38.

40. A method in accordance with claim 39, wherein it includes a Fourier transformation of the interference pattern or the representation of the interference pattern as a linear combination of sinus and/or cosinus functions (e.g. Hartley transformation).

41. A method in accordance with either of claims 39 or 40, wherein the determination of the spectrum includes the breaking down of the measured interference pattern(s) in a set of base patterns dependent on the apparatus, in particular the determination of a spectral component by correlation of the interference pattern(s) with a base pattern prepared for the respective apparatus and the spectral component to be determined.

42. A method in accordance with claim 41, wherein the determination of the spectrally encoded measured value(s) includes the breaking down of the measured interference pattern(s) in a set of apparatus-dependent base patterns, in particular the determination of the spectrally encoded measuring value(s) by correlation of the interference pattern(s) with a base pattern prepared for the respective apparatus and the measured value(s).

43. A method in accordance with either of claims 41 or 42, wherein the base patterns required for the determination of the spectral components or spectrally encoded measured values are gained by a measurement.

44. A method in accordance with one or more of claims 41 to 43, wherein the determination of the spectrum or of the spectrally encoded measured value(s) includes the recording of different interference patterns at different relative phase positions and/or starting from different spatial modes, in particular utilizing at least one of the means named in claims 14, 15, 19, 20, 22, 23 or 24 for the variation of the generated interference patterns.

45. A method in accordance with one or more of claims 41 to 44, wherein the determination of the base patterns includes the recording of different interference patterns at different relative phase positions and/or starting from different spatial modes, in particular utilizing at least one of the means named in claims 14, 15, 19, 20, 22, 23 or 24 for the variation of the generated interference patterns.

46. A method in accordance with one or more of claims 41 to 45 such that respective numerical transformations or functions of one or more interference patterns are used instead of a measured interference pattern or base pattern.

47. A method of preparing patterns in accordance with the method in accordance with claim 46 such that the method includes the determination or measurement of the difference of the optical path lengths of the partial fields brought to interference for the individual measurement points of the patterns and a sorting or indexing of the individual measured values in dependence on the difference of the optical path lengths of the partial fields brought to interference respectively determined for the measurement point.

48. A method for the preparation of base patterns in accordance with the method in accordance with claim 46 such that a Fourier or Hartley transformation is carried out in the sequence of a transformation in accordance with claim 47 (orthogonalization method for base patterns).